Plug into the Grid and Save – Electrification of Diesel Dredges & Boosters

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SUMMARY

With diesel fuel prices expected to hold at $3.00+ per gallon through 2013, converting diesel dredges and booster pumps to electric power can result in a 50% to 60% savings in monthly energy costs. In addition, your operation can achieve up to a 7% increase in tons/hour output while also reducing your dredge downtime. Converting to electric power instead of diesel will also promote sustainability, and in many countries it will provide your contractor customers with LEED points for energy efficient projects. The conversion costs and energy savings analysis will not only highlight an excellent return on investment, it will also indicate a number of additional benefits for conversion, including increased uptime and lower maintenance costs.

Electric conversion can save 50% to 60% in monthly energy costs.

This report will:

- Examine the feasibility of converting diesel powered equipment to electric power
- Illustrate the benefits your operation will achieve by implementing this conversion
    - Calculate the energy cost savings
    - Quantify the financial implications that a conversion has on profitability
- Outline the additional value-added benefits your operation will receive
- Discuss how your operation will better achieve sustainability and LEED score goals

EXAMINING CONVERSION FEASIBILITY

The first step to undertake when determining the feasibility of converting a diesel dredge to an electric powered dredge is to understand how the diesel engine horsepower requirements relate to the electric motor kilowatt requirements. There are many different components on a dredge that require an engine or motor, including the dredge pump itself, the cutter head, the swing winch and the service pump. By examining the horsepower necessary for each of these components, the total horsepower requirements for the dredge can be determined. Table 1 shows a breakdown of the components and a comparison of the requirements for diesel and electric dredges.

Table 1: Horsepower Calculations Diesel Engine Vs. Electric Motor

Components	Diesel Engine	Electric Motor
Dredge Pump	644.56 HP(1)	649.74 HP(6)
Engine Cooling	30.00 HP(2)	0.00 HP(7)
Cutter Head	75.08 HP(3)	75.08 HP
Swing Winch	37.54 HP(4)	37.54 HP
Service Pump	15.00 HP(5)	15.00 HP
Total Average HP	**802.18 HP**	777.36 HP
Electric Drive Efficiency		91%(8)
Actual Average HP Required		**854.24 HP**
Horsepower to kW Conversation	854.24 HP x .7456999 kW(9) = 637.01 kW	

(1) The dredge pump requires 622 HP and has a 96.5% hydrostatic drive efficiency 622/96.5%=644.56HP. (2) The horsepower required for diesel engine radiator cooling. (3) Based on a 130 HP cutter drive, the cutter head consumes approximately 75% of the cutter horsepower during productive swing and approximately 25% of the horsepower on the back swing, the duration of the back swing being approximately half that of the productive swing. (4) The swing winch requirements are 50% of the cutter drive system. (5) The average service water pump has a 20 HP prime mover with and average demand of 75% of the motor. (6) The dredge pump requires 627 HP and has a 96.5% hydrostatic efficiency 627/96.5%=649.74 HP. (7) An electric dredge doesn't require an engine cooler. (8) The adjustment for motor and VFD efficiencies. (9) Standard conversion formula for horsepower to kilowatts.

For this example, we used a DSC model SH-7560-30D dredge. The specifications for this original diesel dredge and the converted electric powered dredge are listed in Table 2. As part of the conversion, a dredge extension section is added to the dredge to increase productivity from 714 tons/hour on the diesel version to 764 tons/hour on the electric version, which results in a net production gain of 50 tons/hour. This production gain is based on the increased length of the dredge after conversion which increases the swing arc. With a larger swing arc, the dredge needs to be moved less often, and movement time is non-productive time. The savings that result from this enhancement are substantial, a 50 tons/hour increase in productivity.

Table 2: Model Comparison Diesel Dredge And Electric Dredge

DSC Dredge Model SH-7650-30D	**DSC Dredge Model SH-7650-30E Extended**
16" x 14" Conventional Diesel Dredge	16" x 14" Conventional Diesel Dredge
CAT C27 Engine—950 HP @ 2,100 RPM	Electric Motor—1,000 HP @ 1,800 RPM
Thomas N40 Pump with 40" dia. Impeller	Thomas N40 Pump with 40" dia. Impeller
130 HP Cutter with a 25' Dredging Depth	130 HP Cutter with a 25' Dredging Depth
Pumping 1,000' on 16" SDR 17 HDPE Pipe	Pumping 1,000' on 16" SDR 17 HDPE Pipe
50' Terminal Elevation	50' Terminal Elevation
Medium Sand & 30' Material Bank Height	Medium Sand & 30' Material Bank Height
714 Tons/Hour Productivity(1)	764 Tons/Hour Productivity(1) (2)
(1) Productivity will vary based on conditions and material being dredged. Source: DSC specifications. (2) Part of the conversion includes adding a dredge extension section which increases productivity.	

BENEFITS TO YOUR OPERATION

To evaluate the full benefit to your operation of this diesel to electric conversion, we will first determine the annual energy cost savings and the increase in production and then look at the initial cost of conversion. By this comparison, we can determine the true impact on profitability.

Determine The Energy Cost Savings

To determine the cost savings of the electric conversion per operational hour, we must calculate the average consumption of diesel fuel in a diesel powered dredge and compare it to the average consumption of electric power in an electric powered dredge. Table 3 shows this comparison, with the diesel dredge operating cost at $130.24 per hour and the electric dredge operating cost at $65.61 per hour.

Table 3: Dredge Energy Consumption

Diesel Dredge	Electric Dredge
Total Average HP Demand = 802.16 HP	Total Average HP Demand = 854.24 HP
802.18 HP / 20.88 g/HP = 38.42 GPH	854.24 HP x .7456999 kW = 637.01 kWh
38.42 GPH x $3.39/gal = $130.24 Per Hour	637.01 kWh x $0.103/kWh = $65.61 Per Hour

In order then to calculate the total net annual cost savings, we need to consider the number of work days and hours employees can work per year, the efficiency of the employees, the uptime and productivity of the dredge, and then factor in the fuel and electric costs.

Table 4: Productivity & Annual Cost Comparison

Diesel Dredge	Electric Dredge	Difference
52 Work Weeks/Year	52 Work Weeks/Year	
x 5 Days/Week	x 5 Days/Week	
260 Work Days Available	260 Work Days Available	
- 6 National Holidays	- 6 National Holidays	
254 Actual Work Days	254 Actual Work Days	
x 10 Hours/Day	x 10 Hours/Day	
x 85% Shift (Worker) Efficiency	x 85% Shift (Worker) Efficiency	
2,159 Hours Available/Year	2,159 Hours Available/Year	
x 95% Dredge Uptime	x 97% Dredge Uptime	2%
2,051 Actual Hour Available/Year	2,094 Actual Hour Available/Year	
x 38.42 Gallons Fuel/Hour	x 637.01 kW/Hour	
78,799.42 Gallons Fuel Annually	1,333,898 kW/Hour	
x $3.39/Gallon Fuel Cost	x $0.103/kW Hour	
$267,136.55 Annual Opt Cost(1)	**$137,406.68 Annual Opt Cost**(1)	**$129,729.87**
		(48.6% Reduction)
2,051.05 Actual Hour Available/Year	2,094.23 Actual Hour Available/Year	
x 714 Tons/Hour, Ave. Productivity(2)	x 764 Tons/Hour, Ave. Productivity(3)	50 Tons/Hour
1,464,449 Tons/Year	1,599,992 Tons/Year	135,543 Tons/Year
		x $8.00/Ton
		$1,084,344.00
Total Savings & Increased Revenue	$129,729.87 +$1,084,344.00 = **$1,214,073.87**	

(1) Does not include maintenance related expenses. (2) Productivity will vary based on type and mixture of material being dredged, source DSC specifications. (3) Part of the conversion includes adding a dredge extension section which will help increase productivity. Productivity will vary based on type and mixture of material being dredged, source DSC specifications.

Electric dredges provide about 2% more uptime than diesel dredges due to the fact that electric motors require less maintenance and repair and also do not require a radiator to cool the power unit. This increase in uptime added to the savings through the lower cost of electricity over diesel fuel leads to an estimated annual operating cost savings of about 48.56% or $129,729.87 per year. In addition, the increased efficiency of the electric dredge can produce an additional 50 tons per hour or 135,543 tons of productivity per year. At an average sales price of $8.00 per ton this equals $1,084,344.00 in additional revenue. The lowered operating cost and additional productivity provide a total of $1,214,073.87 in savings and increased revenue. The complete annual comparison of a diesel and electric dredge in our example are shown in Table 4.

Impact On Profitability

The annual total savings and revenue are only one piece of the puzzle. It is important to also consider the initial cost of converting a diesel dredge into an electric dredge. To do this, we need to consider the cost of new equipment and electric motors, the shore-mounted electrical substation, the transportation costs, and special equipment needed to conduct the conversion and field service-related costs (Table 5).

Table 5: Equipment Required To Complete Conversion

The following motors, drives & equipment are added as part of the conversion:

- Dredge Extension Section
- 1,000 HP Dredge Pump & Hydraulic Electric Motor
- 1,000 HP Variable Frequency Drive (VFD)
- 20 HP Service Water Pump Motor & Switch
- Dredge-Mounted 5 kV Transformer & Switch
- Shore Side Substation 15 kV / 5 kV
- 15 kV Cables From Pole To Substation
- 1,000' Of Floating Power Cable

The total estimated cost to complete the conversion is $1,029,810.00. The breakdown of the different components is summarized in Table 6.

Table 6: Recap Of Estimated Conversion Costs

Equipment Cost	$842,550.00
Shipping Cost	$15,050.00
Crane Cost	$17,326.00
Field Service Cost	$154,884.00
Total Dredge Conversion Cost	**$1,029,810.00**

Now that we have looked at the operating cost savings and the additional revenue that can be achieved by converting a diesel dredge to an electric dredge, we need to compare it to the cost of the conversion and determine what the payback period would be. By using the additional revenue and cost savings identified in Table 3, we can estimate the additional profit and annual payback amount received through this conversion. Since the additional 135,543 tons of productivity is achieved without adding extra manpower or machinery, it would suggest that this additional productivity would be completed at a higher profit percent than the initial productivity. If we estimate the average productivity at a 25% profit margin and the additional productivity to be half as expensive as the initial productivity, this means we would achieve a 62.5% profit margin on this additional productivity (Table 7).

Table 7: Determining Profit Margin Estimates

	Cost	Profit Margin
Standard Productivity Tonnage	75.0%	25.0%
Additional Productivity Tonnage	37.5%	62.5%(1)
(1) Additional productivity tonnage calculated at half the expense of the standard productivity tonnage, standard productivity of 75%/2=37.5%, yielding a 62.5% profit margin on the additional productivity tonnage.		

Based on this adjusted profitability, the additional 135,543 tons of production would equal $1,084,344.00 of added revenue at $8.00 per ton and $677,715.00 of additional profit. If this is added to $129,729.87 of operational savings, we achieve an annual payback of $807,444.87.

When compared to the estimated conversion costs of $1,029,810.00, it would take only 15.3 months to recover the cost (Table 8). The company would add the $806,748.44 in annual payback to its bottom line after that.

Table 8: Conversion Payback Period

Annual Payback Amount	$807,444.87
	÷ 12 Months
Monthly Payback Amount	$67,287.07
Dredge Conversion Cost	$1,029,810.00
Monthly Payback Amount	÷ $67,287.07
Payback Period	15.3 Months

ADDITIONAL VALUE-ADDED BENEFITS

In addition to the benefits already identified, converting a diesel dredge to an electric dredge also has many benefits that will increase your profitability and lower your operating costs, including:

- No engine oil and fuel filter changes
- No oil disposal
- No frequent and risky dredge fueling
- Increased power unit life as electric motors can have a 20 to 30 year service life *(Source: Electrical Apparatus Service Association, EASA)*
- Low maintenance and high reliability due to reduced moving parts

ACHIEVE SUSTAINABILITY AND LEED SCORE GOALS

While there are many obvious financial incentives to the electric conversion, there are substantial additional benefits in many world regions. One very important additional benefit is the positive impact the conversion will have on the environment. Electrical power is cleaner, eliminates the use of diesel fuel and engine oil and provides greater productivity.

Positive environmental improvements can also have positive financial implications. Many projects for public and private entities are now calling for sustainability goals and are giving preference to firms that are positively affecting the environment. There is a point system set up by the US Green Building Council, and many proposals now require reporting of the environmental impact by the contractor, giving preference to higher point values. Conversion to electric power may add to the aggregate contractor's point value, thereby increasing his chances for a successful bid award.

The US Green Building Council's LEED (Leadership in Energy and Environmental Design) Core Concepts Guide promotes sustainable construction. It states: "When applied to build environments, sustainability begins at the inception of an idea and continues seamlessly until the project reaches the end of its life and its parts are recycled or reused. The study of this continual process, known as life-cycle assessment, encompasses planning, design, construction, operations, and ultimately retirement and renewal. The analysis considers not only the building itself but also its materials and components, from their extraction, manufacture, and transport to their use, reuse, recycling, and disposal. The intent of life-cycle assessment is to inform the choice of building materials and systems and thereby minimize the negative impacts of buildings and land use on people and the environment."

The electric dredge process can help achieve greater sustainability and add additional points to a project's LEED certification score. To learn more about sustainability and the LEED program, visit www.usgbc.org.

ASSUMPTIONS

In the example, the following assumptions were used based on currently available data. All calculations are based on estimated average costs. Final costs and savings will vary based on actual conditions and diesel and electric costs at the time of the conversion, but the information and calculations outlined here can be used as a base line and a template.

Table 9: Average Cost Estimates and Conversion Formulas

Key Cost Factors	Cost Breakdown
US Average Electricity Cost	10.3¢/kWh(1)
US Average Diesel Fuel Cost	$3.39/gal(2)
Electrical To Diesel—1 kW	1.3402209 HP(3)
Diesel To Electrical—1 HP	0.7456999 kW(3)
1 Gallon/Hour Consumption	Per 20.88 HP(4)
Average Price Of Material/Ton	$8.00/Ton(5)

(1) Based on Energy Information Administration (EIA): U.S. average energy cost for 2013, includes fuel surcharge, published January 2013, www.eia.gov.(2) Based on Energy Information Administration (EIA): Average of U.S. monthly estimate average diesel costs for 2013, does not include federal and state tax, published January 2013, www.eia.gov.(3) Based on standard conversion rates/methods.(4) Based on the average fuel consumption per horsepower of a CAT C27 ACERT tier II diesel engine across different engine speeds, from 1300 to 2100 rpm. (5) Average price, January 2013.